CHARACTERIZING SOIL-TO-AIR EMISSIONS FROM A CONTAMINATED SITE

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1. - Introduction

Inhalation of volatile chemicals emitted from a contaminated soil might form a major exposure route for people living on site and in the surroundings. It is essential then to quantify ambient air concentrations for characterizing such exposure and assessing the risks for human health.

Two approaches are commonly used :

- Direct **ambient air monitoring** only supplies punctual information which is strongly dependent on the prevailing meteorological conditions. Furthermore, concentrations lying below the analytical detection limits cannot be measured whereas they may be harmful to health, especially in the case of a long term exposure.
- Some exposure models include **transfer functions** which derive concentrations in the atmosphere from those measured in soil or in the soil pore-air. Such functions are based on simplified hypothesis and can ignore site characteristics likely to influence atmospheric dispersion.

To overcome the limitations of both methods INERIS has examined the possibility of using **atmospheric dispersion models**. According to a preliminary modelling study [1], they might be useful tools to produce quantitative maps of short term worst case or long term concentrations, making it possible to delimit the impact area of the emissions from the soil. However, the reliability of the model predictions largely depend on the precision of the input data. In particular the pollution source should be defined very carefully. This is why INERIS has devised a strategy for getting a quantitative spatial representation of soil-to-air fluxes : it combines emission measurements with an original monitoring device and interpolation between the measured values using geostatistical techniques.

2. - Description of the measurement technique

The measurement system was originally designed to monitor methane flows on mining or landfill sites.

It is made of an accumulation chamber connected with an analyser (see Figure 1). Gases emitted from the site within an elementary surface (50 cm x 50 cm) are pumped, sent to the analyser and reinjected into the chamber, creating a recirculating flow. In that way, the atmosphere enclosed in the chamber is enriched with pollutant. The local flux can be easily deduced from the measurement of the atmosphere enrichment as a function of time.

The chamber was tested, validated and calibrated on a test bench and evaluated during a collaborative sampling trial[1]. Field experiments conducted on different sites confirmed the efficiency of the method.

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[1] This sampling trial was managed by the French Agency for the Environment and Energy Resource (ADEME).

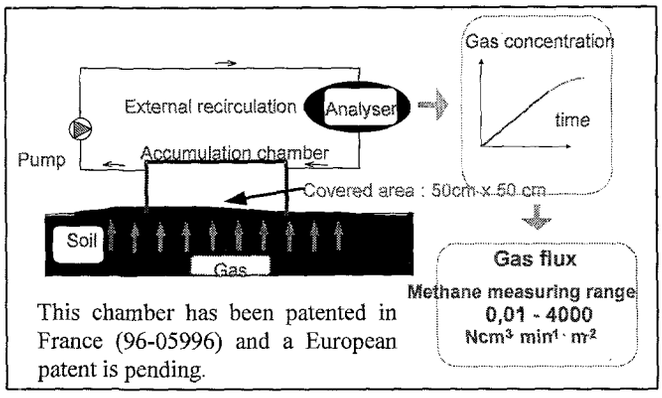

Figure 1 The flux chamber

More recently, developments have been undertaken to adapt the analyser to a wider range of pollutants[2]. Two categories of sensors are used :

- a FID sensor to measure total hydrocarbons fluxes ;
- PID and semiconductor sensors to measure emissions of different product families, such as BTEX or chlorinated solvents.

Their performance was checked in laboratory for several organic compounds, on a real contaminated industrial site for BTEX and on an experimental site (IFARE, Strasbourg) for tri- and tetrachloroethylene [2]. Those field tests have shown the capacity of the measurement system for detecting fluxes as low as 10^{-3} $cm^3/(min.m^2)$. New evaluation experimentations should be carried out this year. In addition to its technical performance the flux chamber presents practical advantages : it is handy and the measuring time at a given point does not exceed a few minutes, which permits to cover a large area in a relatively short time (a couple of days).

3. - Method of emission mapping

The geostatistical kriging technique is a method for interpolating between the measured values with respect to the spatial correlation structure of the studied phenomenon. In our case, the use of such technique is favoured by the dense regular sampling that the measurement system allows to achieve (see previous paragraph). Thus kriging is performed on the emission data to map the estimated soil-to-air fluxes. A source term based on this quantitative representation can be defined and introduced into an atmospheric dispersion model. Furthermore, the kriging variance map provides information about the possible dispersion of the real fluxes around the kriged values, which is useful for estimating uncertainty and conducting a relevant sensitivity analysis.

4. - Conclusion and discussion

In the context of human health risk assessment, a methodology has been worked out for estimating gaseous fluxes from soil to ambient air when volatile compounds are present on site. Successful applications to contaminated areas have demonstrated the feasibility of this approach and enlightened several advantages in terms of performance and costs :

1. The monitoring device has proved reliable and sensitive. Low emission rates can be detected.
2. The flux chamber is handy and the time needed for a single measurement is quite short : so the transport of equipment is not a concern neither the time spent on site. Only one or two days are usually sufficient for characterizing gaseous emissions from a contaminated soil.

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[2] Project funded by the French Ministry of Land Planning and the Environment and by the French company RHODIA RHODITECH (2000-2001)

3. Thanks to a plotter linked to the recorder, the raw results of the measurements can be visualized simultaneously. According to the recorder response the assessor can adjust the location of the next sampling points and modify sampling density if necessary.
4. The methodology developed by INERIS can supply the assessor with a good estimate of the emission area. Provided that all other input data are properly defined, this information may be introduced into an atmospheric dispersion model to map ambient air concentrations over the studied region.
5. The results of emission monitoring may help the assessor to formulate a soil sampling strategy and select borehole locations.

Some aspects of the methodology have to be examined further. This will be done as part of a research programme starting in 2002 :

- The selectivity of the PID and semiconductor sensors needs being improved. This is very important as in most cases, the flux released by a contaminated soil contains several gases.
- The seasonal variations of soil-to-air emissions should be considered when assessing long term exposure.
- Inhalation of chemicals emitted from soil to indoor air may also constitute a significant exposure pathway. This is why the performance of the flux chamber inside buildings located on contaminated soils will be evaluated.

5. - References

1. Baud-Grasset F., Bonnet P., Girardeau Y., Jamois D., Pokryszka Z., Rouïl L., 2000. *Estimating atmospheric transfers from contaminated sites*, Consoil2000, Leipzig, octobre 2000, 727-733.
2. Pokryszka Z., 2001. *Mesures du flux gazeux de composés organochlorés sur le site expérimental de l'IFARE à Strasbourg*. Rapport INERIS, nov. 2001.